Domain Wall Renormalization Group Analysis of the 2-dimentional Square Lattice Ising Model(New Development of Numerical Simulations in Low-Dimensional Quantum Systems: From Density Matrix Renormalization Group to Tensor Network Formulations)

AUTHOR(S):

Aoki, Ken-Ichi; Kobayashi, Tamao; Tomita, Hiroshi

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Ken-Ichi Aoki [1], Tamao Kobayashi [2] and Hiroshi Tomita [3]

Institute for Theoretical Physics, Kanazawa University, Kanazawa, 920-1192, Japan

abstract

We apply a tensor renormalization group method to the 2-dimentional square lattice Ising model. We represent the spin con guration by a domain wall con guration and formulated the domain wall renormalization group (DWRG), by introducing the notion of coarse grained domain wall. We calculate the effective domain wall interactions among the coarse grained domain walls and write down analytically the renormalization group equation in 3-dimensional interaction space. We analyze the flow structure of the renormalization group (see Fig. 1) and derive the 2-phase structure, existence of a xed point (as a root of a fth order algebraic equation), and single relevant operator around that. Numerical analysis gives the critical temperature, critical exponents of the correlation length and the speci c heat. These results are very good compared to the known exact values.

We enlarge the number of states of the domain wall and worked out with 25-dimensional effective interaction space. The obtained physical quantities at the criticality are improved much to give almost exact values within a few %. Magnetization analysis, physical meanings of multi-state domain walls, adding long range interactions of 2-state domain walls, domain wall condensation, higher space dimension, etc. are also to be discussed.

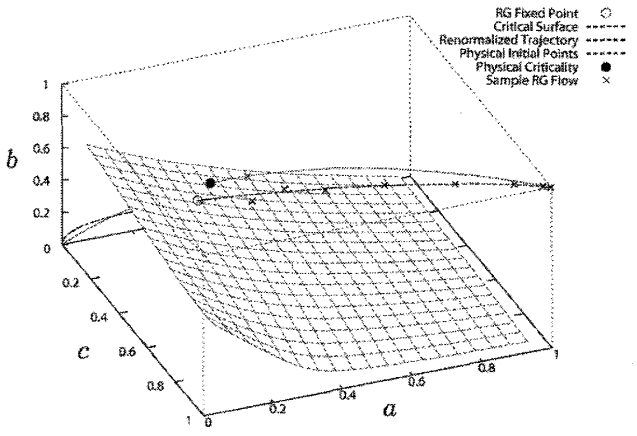

Figure 1: Phase structure of DWRGT

[1]aoki@hep.s.kanazawa-u.ac.jp
[2]ballblue@hep.s.kanazawa-u.ac.jp
[3]t_hirosi@hep.s.kanazawa-u.ac.jp